General Design-Scale Modeling Issues

- How does the particular model simulate rules of operation (flood control, water supply, water quality, and environmental whatever is applicable)?
- How does the model address both horizontal and vertical seepage (including infiltration from impoundments)?
- How does the model address other important aspects of groundwater/surface water interactions (specifically canal/groundwater/surface water interaction)?
- Can the model be linked to any existing water quality simulation code?
- Does the model have the ability utilize high-resolution topographic and hydrostratigraphy that may be collected for project implementation?
- How does the model simulate sheetflow and how is it calibrated?
- Explain how the model can be used to address flood control issues that may be affected by a particular project element
- How does the model address potential impacts of a particular project element (including operational elements) on agricultural areas (specifically South Miami-Dade)
- How is the model calibrated (address both stages and flows; also manual vs. automatic)? What is the general sense of the accuracy?
- Does the model have the capability to provide sensitivity analysis information?
- Can the model perform “Dam-break” type simulations for above ground impoundments?
- How will the model be integrated with existing subregional and regional models?
- How will the model address varying degrees of spatial resolution that may be necessary within the model domain (unstructured vs. structured).
- Can the model be “scaled up or down” easily? Explain the procedure.
- What additional data is needed to apply the model for design purposes?
- What are the expected runtimes for the design applications? Time Step? Hardware requirements?
- What is availability of source code to modelers?
- Explain the ease of model applicability? (any GUIs available or does the modeler have to do lot of manual input). Discuss linkages to existing GIS software.
- What type of documentation is available?
- Has the model been peer-reviewed?
- Has FEMA accepted the model for flood control applications?
- What are the data requirements for the model

CERP Components Listed by Type

In-ground Reservoir

CERP requires the construction of several in ground reservoirs that provide most of their storage below ground surface. Most of these reservoirs will be constructed by converting aggregate mining pits (ranging in depth from 30 to 50 feet) using subterranean seepage barriers and embankments. Site specific models will be needed to evaluate the type, depth, and thickness required to successfully store water in the proposed locations. The water level in these reservoirs is expected to fluctuate by as much as 36 feet (e.g. 21 feet below land surface and 15 feet above ground surface) which is sufficient to make the hydraulic migration of fines (piping) a significant risk. The modeling or analysis will be needed to estimate seepage rates and regional impacts and provide information sufficient for design of the seepage barriers or seepage collection systems or a combination of both.

Summary of Important Issues

- Seepage out of reservoirs

- Groundwater flow
- Base flows into canals
- How does the model handle impervious barrier systems like grout curtains, geomembranes or slurry walls?
- How does the model handle "internal model boundaries" such as low heads inside of the in-ground reservoirs? Can you use flux in or out or do you have to set a constant head? Just setting a constant head would be in-adequate for detailed design of these features as you must determine the amount of inward leakage you need to control to maintain a certain head.

Specific Projects
- **Central Lake Belt Storage Area - Component S6** (5,200 acres with subterranean seepage barrier around the perimeter) in Miami-Dade County. Purpose: receive and store excess water from Water Conservation Area (WCA) 2B, 3A and 3B.
- **North Lake Belt Storage Area - Component XX6** (4,500 acres with subterranean seepage barrier around the perimeter) in Miami-Dade County. Purpose: increase regional water resources by capturing a greater portion of runoff from western C-6, western C-11 and C-9 basins in the in-ground storage area. The stored water will be used to maintain stages during the dry season in the C-9, C-6, C-7, C-4 and C-2 Canals.

ASR

A regional (District-wide or peninsula-wide) Floridan Aquifer model will be needed to evaluate the cumulative impacts of the CERP ASR components. The model must include density-dependent groundwater flow, and will be used to simulate regional groundwater flow (increase and decrease in potentiometric surface) and the change in size of the fresh-water “bubbles” created by the ASR systems. This type of information will be required by the FDEP to permit the ASR systems, and it will also help answer some concerns from the scientific community.

It will also be necessary to “zoom in” from the regional Floridan Aquifer model to individual ASR systems. The “zoom” model will be used to simulate the interaction of the fresh-water bubble within individual well clusters, and to evaluate the impacts (i.e. change in potentiometric heads) on existing users. Once again, this information will be required for FDEP to permit individual ASR wells, and will also be necessary to get a Water Use Permit for the operation of the system.

Finally, some of these ASR projects are proposing using groundwater from the Surficial Aquifer for storage. In those cases, a Surficial Aquifer model will be needed to evaluate the effects (drawdowns) those withdrawals will have on existing groundwater users. This would be required for the Water Use Permits.

Summary of Important Issues
- Density dependent ground water flow
- Drawdown
- Interaction of freshwater bubble with saline aquifer
- What type of geochemical mixing/reactions can be modeled in the code? Do you need to link to a separate code to address these concerns?
- Can the code be linked to a GUI to produce data animations or high level graphical output to be utilized to brief stake holders and the public?
- What kinds of input data is mandatory to run the density driven portion of the model ? Do you utilize effective porosity, bulk density, dispersivity, etc... ?

Specific Projects
- Lake Okeechobee Aquifer Storage and Recovery
- C-43 Basin Storage Reservoir and Aquifer Storage and Recovery
- C-51 Regional Groundwater Aquifer Storage and Recovery
- Palm Beach County Agricultural Reserve Reservoir and Aquifer Storage and Recovery

- Site 1 Impoundment and Aquifer Storage and Recovery

Reuse

We need the ability to simulate the use of reclaimed water to supplement existing freshwater deliveries and/or replace these deliveries, ground water recharge and a reduction of freshwater demands for irrigation with use of reclaimed water. We are using the West Palm Beach Pilot Project to gather information on treatment technologies to reduce constituents found in treated wastewater. This information will be used to investigate further the potential of using reclaimed water to supplement freshwater flows to Biscayne Bay by discharging reclaimed water to wetlands along Biscayne Bay and for recharging the Biscayne Aquifer. It is assumed this application will improve water to south Miami-Dade County and reduce seepage from Northeast Shark River Slough.

In western Miami-Dade County, a feasibility study is underway identifying potential uses of reclaimed water in the Bird Drive Basin. Potential uses include the use of reclaimed for urban and agricultural irrigation, introduction into natural systems, ground water recharge, and introduction into surface water features. Volumes could be on the order of 50 to 100 MGD.

Although not directly recommended by CERP, the District is working with utilities and other agencies investigating the use of reclaimed to maintain canal stages in secondary systems and replace water currently taken from the regional system. This could involve several hundred million gallons per day, and could also be considered a contingency if ASR and reservoirs do not perform as assumed.

Summary of Important Issues
- Groundwater Flows
- Canal Flows
- Groundwater/Surface Water Interactions in canals
- ET and Recharge
- Wetland/Overland Flows

Specific Projects
- Palm Beach County Wetlands Based Water Reclamation
- West Miami-Dade County Reuse
- South Miami-Dade County Reuse

Wellfield

The primary concerns regarding wellfields are saltwater intrusion and local area impacts. Neither the US Army Corps of Engineers nor the South Florida Water Management District has any direct authority over or responsibility for water supply utilities. Consequently, there are no components addressing wellfields in the Comprehensive Everglades Restoration Plan. Projected population increases with consequent increased water demand were a direct cause of adverse impacts on various wellfields in the Lower East Coast area as reflected in future base conditions of regional model runs. Since the individual utilities have the responsibility to ascertain whether wellfield relocation or development of alternative water supply sources will meet future demands, the assumption was made for modeling purposes to relocate wellfields inland to remove saltwater intrusion caused by excessive drawdown. Due to the wet and dry seasons in South Florida and the shallow production aquifer, wellfield operations often change with the seasons and are susceptible to other concerns such as surface water pollutants and industrial wastewater. Highly transmissive conditions exist in Miami-Dade County and to a lesser degree in Broward County.

Summary of Important Issues
- Saltwater intrusion
- Groundwater interaction with wetlands and canals

- Accurate computation of cones of depression

Specific Projects

- L-31N Levee Improvements for Seepage Management and S-356 Structures

Routing Water – Pumps / Structures / Dredging / Filling / Speader Canals and Swales

Except for those canals specifically identified as seepage canals, the primary canal criterion involves flood protection. Although the major canals also provide water supply conveyance routes, the deliveries are mainly during the dry season when seepage outflow is a concern. Flood protection considerations include routes for discharge to tide but also regulatory releases from Lake Okeechobee and seepage inflow due to high ground water levels. The primary canals were designed to support a population base of approximately two million people; currently over six million people live in South Florida and twelve to fifteen million are expected by 2050. Therefore, surface water runoff and flood protection are primary concerns. High transmissivity of soils in Miami-Dade and Broward counties drives surface water and groundwater interaction concerns and the shallow drinking water aquifer makes water quality a major concern. The encroachment of urbanized areas and the agricultural area discharges provide a source of concern for water quality impacts on the environment in addition to drinking water concerns. Other factors for routing of water include prevention of saltwater intrusion and groundwater and wellfield recharge.

Summary of important issues

- Ability to compute conveyance capacity and water surface profiles
- Ability to accurately represent channel cross sections and roughness coefficient. Does the model have the ability to specify a flood plane that has different properties than the main channel ?
- Ability to model channel restrictions
- Ability to calculate inflow for design storms and actual events (hydrologic component)
- Groundwater / Surface water interactions
- Ability to simulate structures, culverts and pump stations (including sluice gates, tainter gates, weirs and culvert with risers)
- Ability to handle reverse flow
- Ability to model “triggers” that control structure operations. Types of triggers that must be modeled include seasonal/date specified and headwater/tailwater dependent.

Specific Projects

- Lake Okeechobee Tributary Sediment Dredging
- Big Cypress/L-28 Interceptor Modifications
- Flow to Northwest and Central Water Conservation Area
- Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement
- Loxahatchee National Wildlife Refugee Internal Canal Structures
- Biscayne Bay Coastal Wetlands
- Diverting Water Conservation Area 2 and 3 flows to
- Central Lake Belt Storage
- C-111N Spreader Canal
- C-4 Control Structures
- Broward County Secondary Canal System
- Dade-Broward Levee/Pennsuco Wetlands
- L-31N Levee Improvements for Seepage Management and S-356 Structures

Above Ground Impoundment - Storage

CERP requires the construction of numerous above ground reservoirs. These reservoirs will be created by constructing embankments to contain water above ground surface. The storage depths of these impoundments currently range from 4 to 12 feet. However, the goal is to identify cost effective ways to increase storage depths when possible. Site specific models will be needed to estimate seepage rates and evaluate the effectiveness of seepage controls such as those listed below.

- embankment material permeability,
- site preparation,
- embankment geometry
- depth, width, location of a seepage collection canal, and seepage rate
- use of seepage reduction methods such as seepage prevention blankets
- horizontal wells as toe drains to control and capture seepage an as ASR source water
- shallow slurry walls

Modeling or analysis will be needed to estimate seepage rates and regional impacts and provide information sufficient for design of the embankment, seepage reduction devices, and seepage collection systems. This modeling may be difficult due to the high transmissivity of the underlying aquifer at some locations.

Summary of important issues

- Seepage
- Ability to model seepage management devices (slurry walls, horizontal wells, …)
- Wetland/Overland flow in Storage areas
- Groundwater flow
- Groundwater/Surface water interactions
- Performance of created wildlife enhancement areas associated with storage areas. Florida Fish and Wildlife Commission is concerned that these areas may become sinks for fish making them unavailable to wading birds and are interested in the following:
  - Hydroperiod
  - Duration of uninterrupted flooding
  - Number of acres at a particular depth
  - Extreme high and low water events

Specific Projects

- Component A6. A Storage Reservoir (20,000 acres at 10 ft. maximum depth) north of Lake Okeechobee. Purpose: incorporate climate-based inflow forecasting to increase the utilization of the reservoir to provide additional flood protection, water supply and environmental enhancement. Operation revised from Alternative 5.
- Component B2. A Storage Reservoir (10,000 acres at 4 ft. maximum depth) in the St. Lucie basin. Purpose: capture local runoff from C-44 for flood attenuation, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.
- Component UU6 D13R. Storage Reservoirs (26,200 acres at 8 ft. maximum depth and 9,350 acres at 4 ft. maximum depth) in Martin and St. Lucie Counties. Purpose: capture local runoff from the C-23, 24, and Northfork and Southfork Basins of the St. Lucie River Estuary for flood flow attenuation to the estuary, water supply benefits including environmental water supply deliveries to the estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The reservoirs were increased in size and reconfigured from the design presented in Alternative 5.
- Component G6. A Storage Reservoir (one 20,000 acre compartment at 6 ft. maximum depth for supplying EAA irrigation demands and two 20,000 acre compartments at 6 ft. maximum depth for supplying environmental demands) in the Everglades Agricultural Area with increased conveyance from Lake Okeechobee to the reservoir. Purpose: improve timing of environmental deliveries to the

Water Conservation Areas including reducing damaging flood releases from the EAA to the Water Conservation Areas, reduce Lake Okeechobee regulatory releases to estuaries, meet supplemental agricultural irrigation demands and increase flood protection within the Everglades Agricultural Area. Conveyance capacity of the Miami, North New River, Bolles and Cross Canals between Lake Okeechobee and the Storage Reservoirs are increased to convey additional Lake Okeechobee regulatory releases that would have otherwise been discharged to the Caloosahatchee and St. Lucie Estuaries. In Alternative 5, the two compartments were modified to operate as a dry storage areas with withdrawals being made down to 18" below ground level. It was also been subdivided into two 20,000-acre compartments to allow for more efficient use of the reservoir and for alternative uses of the compartments during dry times (i.e. agriculture).

- Component GGG6. C-51 and Southern L-8 Reservoir (1200 acres with 40 ft. of working storage depth) in Palm Beach County. Purpose: reduce the number, magnitude and volume of discharges to the Lake Worth Lagoon, provide water supply deliveries to the Northwest Fork of the Loxahatchee River, Lake Worth Drainage District and the West Palm Beach Water Catchment Area, and provide flood peak attenuation to the C-51 and southern L-8 basins.
- North of Lake Okeechobee Storage Reservoir
- C-44 Basin Storage Reservoir
- Northfork and Southfork Storage Reservoirs
- Everglades Agricultural Storage Reservoirs
- Water Preserve Areas / L-8 Basin
- Acme Basin B Discharge
- Site 1 Impoundment and Aquifer Storage and Recovery
- Western C-11 Diversion Impoundment and Canal
- C-9 Stormwater Treatment Area/Impoundment
- Bird Drive Recharge Area
- Water Conservation Areas 3A and 3B Levee Seepage Management

Environmental/Wetland

The majority of the Everglades Protection Area has been compartmentalized into hydrologically separate reservoirs. The five largest compartments consist of the Water Conservation Areas; they are completely contained by levees except for about seven miles on the west side of WCA 3A, which has a tie-back levee. The Central and Southern Florida Project is managed with a system of canals, pump stations and control structures. Its current operating schedule does not mimic natural rainfall patterns and precludes seasonal water fluctuations and sheetflow associated with the Everglades. Although most of the projects listed are outside of the Water Conservation Areas, they have similar problems due to being severed from their historical sources of water. Most of the projects listed focus on delivering water to more closely mimic historical quantities and timing of deliveries. The means to deliver water, distribute it, and control it (prevent it from seeping) varies among the projects listed due to different ecological and geologic features. The key is to understand the water regime that sustains the natural resources and obtain similar performance given the constraints of the current water management system, e.g. flood mitigation.

Performance measures or output from hydrologic models desirable to evaluate natural features consist of several types depending on the resource. For ridge and slough, marl prairie, and cypress wetlands, groundwater measures include seepage and flow; and surface water measures include several variation of stage information - hydroperiod, number of dry events, duration of uninterrupted flooding, extreme high and low water events, seasonal distribution of overland flow, and total overland flow.

Summary of Important Issues

- Seepage
- Hydroperiod
- Duration of uninterrupted flooding
- Extreme high and low water events
- Seasonal variations in water depth on both an intra and inter annual basis

Specific Projects

- Lake Worth Lagoon Restoration
- Winsburg Farms Wetland Restoration
- Southern Golden Gate Estates Restoration
- Southern CREW Project Addition
- Lake Trafford Restoration
- Henderson Creek/Belle Meade Restoration
- Lake Park Restoration
- Florida Keys Tidal Restoration
- Restoration of Pineland & Hardwood Hammocks in C-111 Basin
- Biscayne Bay Coastal Wetlands
- Protect and Enhance Existing Wetland Systems along Loxahatchee National Wildlife Refuge including the Strazzulla Tract
- Melaleuca Eradication Project and other Exotic Plants
- Water Conservation Areas 3A and 3B Levee Seepage Management
- Lake Istokpoga Regulation Schedule
- Seminole Tribe Big Cypress Water Conservation Plan
- Pal-Mar and J.W. Corbett Wildlife Management Area
- Hydropattern Restoration
- Miccosukee Water Management Plan

Water Quality Treatment in Above Ground Impoundment (***to be discussed at a future date***)

Section 528 of the Water Resources Act of 1996 requires that the comprehensive CERP Plan includes water quality features necessary to provide water to restore, preserve, and protect the south Florida ecosystem. In compliance with this act, the comprehensive CERP Plan includes numerous water quality improvement features that, when fully implemented, will help toward meeting water quality objectives for many watersheds and CERP components within South Florida. These water quality features are a part of the comprehensive water quality plan within the CERP which aims at making recommendations for water quality remediation programs and the integration of water quality restoration targets into future design, construction, and operation activities as features of the recommended CERP Plan. One the key driving force behind the CERP is to divert water into impoundments for storage and water supply purposes. The water stored in reservoirs will be used at a later date to meet water supply demands, recharge aquifers or provide water to maintain fauna and flora in natural areas. For these purposes, it is necessary that the water released from reservoirs be of good quality and meet the state and local water quality standards for water bodies this water will be released into.

Given that these reservoirs or impoundments are not yet built, models are necessary to design them, to predict their performance in terms of pollutant reduction before waters are discharged into sensitive areas, and to interpret their performance in terms of pollutant load reduction. The latter function is a necessary feedback to optimize the design of the reservoirs. The reservoirs themselves when well designed can operate as reliable source of pollutant reduction (Walker, 1998; Renchow 1992). In some cases when water quality are strict, Stormwater Treatment Areas (STAs) are used for additional treatment of reservoir outflow water before it is released in sensitive areas. Those STAs are constructed marsh-land that reduce pollutant concentration by plant uptake or dynamic or quiescent settling in the peat soils. About 35,000 acres of those STAs are used in the CERP comprehensive plan in addition to the 181,000 acres of reservoir area proposed. The use of these additional areas emphasizes the effort in the CERP to address water quality issues. Models such as Walker's Phosphorus based model (1998) were used to size the STAs. Walker's reservoir model was also used in conjunction with the SFWMM (2X2) flows to show that with proper residence times and hydroperiods, reservoirs can effectively be used as sinks for water quality pollutant. However, the models used in this planning phase are large time scale models (yearly time step) and may not be effective in providing the information needed for a good understanding of pollutant dynamics in STAs and reservoirs. The modeling effort needed now is to select or develop shorter time scale (weekly, daily, monthly) water quality models for both reservoirs and STAs. The model development or selection could be extended to basin level modeling, in the sense that the quality of the water captured at the basin level needs to be accurately known. In that aspect, calibrated landuse-based water quality models will also be needed to determine the quality of the water to be stored into reservoirs. A good knowledge of the diverted water quality is necessary in optimizing the effectiveness of the reservoirs and STAs as water quality improvement tools. A few short time scale model are being developed now. One of these models is Bill Walker's Dynamic STA model (DMSTA). The model is now being calibrated. A basin scale water quality model is being developed (selected) by contractual work (District sponsored modeling effort. A pollutant load screening model (basin scale model) is also being calibrated by John Zahina of the District. Any other model that can be used in the assessment of water quality for reservoirs or basins for the South Floridan conditions can help assess water quality within the CERP domain.

Another water quality modeling area of importance is the assessment of fate of pollutant for deep reservoirs such as the LakeBelt Reservoirs. These reservoirs cannot be modeled with shallow lake and reservoir models. In addition to surface water modeling, the interaction ASR waters (Groundwater) and reservoirs waters needs to be assessed, generally in areas where the reservoir is built with adjacent ASR wells.

Specific Projects

- Taylor Creek/Nbbin Slough Storage and STA (Component W2):
- Lake Okeechobee Watershed Water Quality Treatment Facilities (Component A6)
- Calosahatchee Backpumping with STA (Component DDD5)
- ACME Basin B Discharge (OPE)
- C-17 Backpumping and Treatment (Component X6)
- C-51 Backpumping and Treatment (Component Y6)
- C-9 Impoundment (Component R4)

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